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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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In re Reissue Application of:	:	
	)	Examiner: L. Alejandro
NOBUMASA SUZUKI	:	
	)	
Application No.: 09/657,971	:	Group Art Unit: 1763
	)	
Filed: September 8, 2000	:	
	)	
For: MICROWAVE PLASMA	:	
PROCESSING APPARATUS AND	)	
METHOD THEREFOR	:	
	)	September 17, 2001

BOX REISSUE
Commissioner for Patents
Washington, D.C. 20231

RESPONSE TO NOTICE OF NON-COMPLIANT AMENDMENT

Applicants hereby respond to the Notice of Non-Compliant Amendment dated September 7, 2001.

The Notice indicates that the amendment dated August 28, 2001 did not include a clean copy of the claims.

Applicants now submit a clean copy of all the pending claims which was inadvertently omitted from the Amendment.

The Examiner is kindly requested to contact the undersigned attorney in the event further information is needed.

Applicant's undersigned attorney may be reached in our New York office by telephone at (212) 218-2100. All correspondence should continue to be directed to our address given below.

Respectfully submitted,

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1. A microwave plasma processing apparatus comprising:

a plasma generation chamber whose periphery is separated from ambient air by a dielectric member;

microwave introduction means utilizing an endless annular wave guide tube provided around said plasma generation chamber and having plural slots;

a processing chamber connected to said plasma generation chamber;

support means for a substrate to be processed, provided in said processing chamber;

gas introduction means for said plasma generation chamber and said processing chamber; and

evacuation means for said plasma generation chamber and said processing chamber;

wherein a circumferential length L_g of said endless annular wave guide tube, a wavelength λ_g of the microwave in said endless annular wave guide tube, a circumferential length L_s of said dielectric member and a wavelength λ_s of the surface wave propagating in said dielectric member substantially satisfy a relationship:

$$L_s/\lambda_s = (2n + 1)L_g/\lambda_g$$

wherein n is 0 or a natural number.

2. A microwave processing apparatus according to claim 1, further comprising magnetic field generation means.

3. A microwave processing apparatus according to claim 2, wherein said magnetic field generation means is adapted to control the magnetic field in the vicinity of the slots at a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

4. A microwave processing apparatus according to claim 1, wherein said substrate support means is provided at a position distant from a generation area of said plasma.

5. A microwave processing apparatus according to claim 1, further comprising means for irradiating the substrate to be processed with optical energy.

6. A microwave processing apparatus according to claim 5, wherein said optical energy includes ultraviolet light.

7. A microwave processing apparatus according to claim 1, further comprising high frequency supply means connected to said support means.

8. A microwave processing apparatus according to claim 1, wherein said wave guide tube is provided therein with a dielectric material.

9. A microwave processing apparatus according to claim 1, wherein said wave guide tube is provided therein with a dielectric material which is different from said dielectric member.

10. A microwave plasma processing apparatus comprising:

a plasma generation chamber whose periphery is separated from ambient air by a dielectric member;

microwave introduction means utilizing an endless annular wave guide tube provided around said plasma generation chamber and having plural slots;

a processing chamber connected to said plasma generation chamber;

support means for a substrate to be processed, provided in said processing chamber;

gas introduction means for said plasma generation chamber and said processing chamber; and

evacuation means for said plasma generation chamber and said processing chamber;

wherein a central radius R_g of said endless annular wave guide tube, a wavelength λ_g of the microwave in said endless annular wave guide tube, a central radius R_s of the dielectric member and a wavelength λ_s of the surface wave propagating in said dielectric member substantially satisfy a relationship:

$$R_s/\lambda_s=(2n+1)R_g/\lambda_g$$

wherein n is 0 or a natural number.

11. A microwave processing apparatus according to claim 10, further comprising a magnetic field generation means.

12. A microwave processing apparatus according to claim 11, wherein said magnetic field generation means is adapted to control the magnetic field in the vicinity of the slots at a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

13. A microwave processing apparatus according to claim 10, wherein said substrate support means is so provided as to place the substrate at a position distant from a generation area of said plasma.

14. A microwave processing apparatus according to claim 10, further comprising means for irradiating the substrate to be processed with optical energy.

15. A microwave processing apparatus according to claim 14, wherein said optical energy includes ultraviolet light.

16. A microwave processing apparatus according to claim 10, further comprising high frequency supply means connected to said support means.

17. A microwave processing apparatus according to claim 10, wherein said wave guide tube is provided therein with a dielectric material.

18. A microwave processing apparatus according to claim 10, wherein said wave guide tube is provided therein with a dielectric material which is different from said dielectric member.

19. (Amended) A microwave plasma processing apparatus comprising:

a plasma generation chamber provided with a first dielectric material;

a processing chamber connected to said plasma generation chamber;

means for supporting a substrate to be processed, provided in said processing chamber;

microwave introduction means utilizing an endless annular wave guide with a plurality of slots for radiating microwaves therethrough provided outside of said first dielectric material;

means for introducing gas for said plasma generation chamber and said processing chamber; and

evacuation means for said plasma generation chamber and said processing chamber;

wherein an interior of said annular wave guide tube is filled with a second dielectric material which is the same as or different from said first dielectric material so that the wavelength of microwaves in said wave guide is shortened.

20. A microwave processing apparatus according to claim 19, wherein a ratio of dielectric constants of said first and second dielectric materials is approximately equal to a reciprocal of a square of the ratio of circumferential lengths of said first and second dielectric materials.

21. A microwave processing apparatus according to claim 19, further comprising a magnetic field generation means.

22. A microwave processing apparatus according to claim 21, wherein the magnetic field in the vicinity of the slots has a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

23. A microwave processing apparatus according to claim 19, wherein said substrate support means is provided at a position distant from a generation area of said plasma.

24. A microwave processing apparatus according to claim 19, further comprising means for irradiating the substrate to be processed with optical energy.

25. A microwave processing apparatus according to claim 19, further comprising high frequency supply means connected to said support means.

26. A microwave plasma processing method utilizing a microwave plasma processing apparatus comprising a plasma generation chamber whose periphery is separated from ambient air by a dielectric member; microwave introduction means utilizing an endless annular wave guide tube provided around said plasma generation chamber and provided with plural slots; a processing chamber connected to said plasma generation chamber; support means for a substrate to be processed, provided in said processing chamber; gas introduction means for said plasma generation chamber and said processing chamber; and evacuation means for said plasma generation chamber and said processing chamber; adapted to effect a plasma process on said substrate by selecting a circumferential length L_g of said endless annular wave guide tube, a wavelength λ_g of the microwave in said endless annular wave guide tube, a circumferential length L_s of said dielectric member and a wavelength λ_s of the surface wave propagating in said dielectric member so as to substantially satisfy a relationship:

$$L_s/\lambda_s = (2n+1)L_g/\lambda_g$$

wherein n is 0 or a natural number.

27. A microwave processing method according to claim 26, wherein the plasma process is effected under application of a magnetic field.

28. A microwave processing method according to claim 27, wherein said magnetic field is so controlled that the magnetic field in a vicinity of the slots is at a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

29. A microwave processing method according to claim 26, comprising a step of placing said substrate on said substrate support means at a position distant from a generation area of said plasma.

30. A microwave processing method according to claim 26, wherein the plasma process is effected under irradiation of the processed substrate with optical energy.

31. A microwave processing method according to claim 30, wherein said optical energy includes ultraviolet light.

32. A microwave processing method according to claim 26, wherein the plasma process is effected by supplying high frequency to said support means.

33. A microwave processing method according to claim 26, wherein an interior of said wave guide tube is filled with a dielectric material.

34. A microwave processing method according to claim 26, wherein an interior of said wave guide tube is filled with a dielectric material which is different from said dielectric member.

35. A microwave processing method according to claim 26, wherein said plasma process is film forming.

36. A microwave processing method according to claim 26, wherein said plasma process is etching.

37. A microwave processing method according to claim 26, wherein said plasma process is ashing.

38. A microwave plasma processing method utilizing a microwave plasma processing apparatus comprising a plasma generation chamber whose periphery is separated from ambient air by a dielectric member; microwave introduction means utilizing a cylindrical endless annular wave guide tube provided around said plasma generation chamber and provided with plural slots; a processing chamber connected to said plasma generation chamber; support means for a substrate to be processed, provided in the processing chamber; gas introduction means for said plasma generation chamber and said processing chamber; and evacuation means for said plasma generation chamber and said processing chamber, adapted for effecting a plasma process by selecting a central radius R_g of said endless annular wave guide tube, a wavelength λ_g of the microwave in said endless annular wave guide tube, a central radius R_s of said dielectric member and a wavelength λ_s of the surface wave propagating in said dielectric member so as to substantially satisfy a relationship:

$$R_s/\lambda_s = (2n+1)R_g/\lambda_g$$

wherein n is 0 or a natural number.

39. A microwave processing method according to claim 38, wherein the plasma process is effected under application of a magnetic field.

40. A microwave processing method according to claim 39, wherein said magnetic field is so controlled that the magnetic field in a vicinity of the slots is at a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

41. A microwave processing method according to claim 38, comprising a step of placing said substrate on said substrate support means at a position distant from a generation area of said plasma.

42. A microwave processing method according to claim 38, wherein the plasma process is effected under irradiation of the processed substrate with optical energy.

43. A microwave processing method according to claim 42, wherein said optical energy includes ultraviolet light.

44. A microwave processing method according to claim 38, wherein the plasma process is effected by supplying high frequency to said support means.

45. A microwave processing method according to claim 38, wherein an interior of said wave guide tube is filled with a dielectric material.

46. A microwave processing method according to claim 38, wherein an interior of said wave guide tube is filled with a dielectric material which is different from said dielectric member.

47. A microwave processing method according to claim 38, wherein said plasma process is film forming.

48. A microwave processing method according to claim 38, wherein said plasma process is etching.

49. A microwave processing method according to claim 38, wherein said plasma process is ashing.

50. (Amended) A microwave plasma processing method wherein a substrate is placed in a microwave plasma processing apparatus comprising a plasma generation chamber provided with a first dielectric material; a processing chamber connected to the plasma generation chamber; means for supporting a substrate to be processed, to be placed in the processing chamber; microwave introduction means utilizing an endless annular wave guide provided with plural slots for radiating microwaves therethrough provided outside of said first dielectric material; means for introducing gas for said plasma generation chamber and said processing chamber; and evacuation means for said plasma generation chamber and said processing chamber, wherein the interior of said annular wave guide tube is filled with a second

dielectric material which is the same as or different from the first dielectric material, so that the wavelength of microwaves in said wave guide is shortened, thereby effecting a plasma process.

51. A microwave processing method according to claim 50, wherein a ratio of the dielectric constants of said first and second dielectric materials is approximately equal to a reciprocal of a square of a ratio of circumferential lengths of said first and second dielectric materials.

52. A microwave processing method according to claim 50, wherein said plasma process is effected under application of a magnetic field.

53. A microwave processing method according to claim 52, wherein the magnetic field in a vicinity of the slots has a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

54. A microwave processing method according to claim 50, comprising a step of placing said substrate on said substrate support means at a position distant from a generation area of said plasma.

55. A microwave processing method according to claim 50, wherein the plasma process is effected under irradiation of the substrate with optical energy.

56. A microwave processing method according to claim 50, wherein the plasma process is effected by supplying high frequency to said support means.

57. A microwave processing method according to claim 50, wherein said plasma process is film forming.

58. A microwave processing method according to claim 50, wherein said plasma process is etching.

59. A microwave processing method according to claim 50, wherein said plasma process is ashing.

60. (Amended) A microwave plasma processing apparatus comprising:

a plasma generation chamber provided with a first dielectric material;

means for supporting a substrate to be processed;

microwave introduction means utilizing an endless annular wave guide with a plurality of slots for radiating microwaves therethrough provided outside of said first dielectric material;

means for introducing gas into said plasma generation chamber; and

evacuation means for said plasma generation chamber;

wherein an interior of said wave guide is filled with a second dielectric material which is the same as or different from said first dielectric material so that the wavelength of microwaves in said wave guide is shortened.

61. A microwave processing apparatus according to claim 60, where the wave guide has a cylindrical shape.

62. A microwave processing apparatus according to claim 60, where the wave guide has a disk shape.

63. A microwave processing apparatus according to claim 60, where the wave guide has a shape which follows the exterior of the first dielectric material.

64. A microwave processing apparatus according to claim 60, further comprising a processing chamber connected to said plasma generation chamber.

65. A microwave processing apparatus according to claim 64, where the wave guide has a cylindrical shape.

66. A microwave processing apparatus according to claim 64, where the wave guide has a disk shape.

67. A microwave processing apparatus according to claim 64, where the wave guide has a shape which follows the exterior of the first dielectric material.

68. (Amended) A microwave plasma processing apparatus comprising:

a plasma generation chamber provided with a first dielectric material;

a substrate support for a substrate to be processed, located inside the plasma generation chamber;

an endless annular wave guide with a plurality of slots for radiating microwaves therethrough provided outside of said first dielectric material;

gas inputs situated to introduce gas into said plasma generation chamber;

an evacuation system situated to permit pressure reduction in said plasma generation chamber;

wherein an interior of said wave guide is filled with a second dielectric material which is the same as or different from said first dielectric material so that the wavelength of microwaves in said wave guide is shortened..

69. A microwave processing apparatus according to claim 68, where the wave guide has a cylindrical shape.

70. A microwave processing apparatus according to claim 68, where the wave guide has a disk shape.

71. A microwave processing apparatus according to claim 68, where the wave guide has a shape which follows the exterior of the first dielectric material.

72. A microwave processing apparatus according to any one of claims 60-71, wherein a ratio of dielectric constants of said first and second dielectric materials is approximately equal to a reciprocal of a square of the ratio of circumferential lengths of said first and second dielectric materials.

73. A microwave processing apparatus according to any one of claims 60-71, further comprising a magnetic field generator.

74. A microwave processing apparatus according to claim 73, wherein the magnetic field in the vicinity of the slots has a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

75. A microwave processing apparatus according to any one of claims 60-71, wherein said substrate support is provided at a position distant from a generation area of said plasma.

76. A microwave processing apparatus according to any one of claims 60-71, further comprising an optical energy source to irradiate the substrate.

77. A microwave processing apparatus according to any one of claims 60-71, further comprising a high frequency supply connected to said substrate support.

78. (Amended) A microwave plasma processing method wherein a substrate is placed in a microwave plasma processing apparatus comprising a plasma generation provided with a first dielectric material; means for supporting a substrate to be processed; microwave introduction means utilizing an endless annular wave guide provided outside of said plasma generation chamber and provided with plural slots for irradiating microwaves therethrough; means for introducing gas for said plasma generation chamber; and evacuation means for said plasma generation chamber, wherein the interior of said wave guide is filled with a second dielectric material which is the same as or different from the first dielectric material, so that the wavelength of microwaves in said wave guide is shortened, thereby effecting a plasma process.

79. A microwave plasma processing method according to claim 78, wherein the microwaves are introduced utilizing a cylindrically-shaped wave guide.

80. A microwave plasma processing method according to claim 78, wherein the microwaves are introduced utilizing a disk-shaped wave guide.

81. A microwave plasma processing method according to claim 78, wherein the microwaves are introduced utilizing a waveguide which has a shape which follows the exterior of the first dielectric material.

82. A microwave plasma processing method according to claim 78, further comprising using a processing chamber connected to said plasma generation chamber.

83. A microwave plasma processing method according to claim 82, wherein the microwaves are introduced utilizing a cylindrically-shaped wave guide.

84. A microwave plasma processing method according to claim 82, wherein the microwaves are introduced utilizing a disk-shaped wave guide.

85. A microwave plasma processing method according to claim 82, wherein the microwaves are introduced utilizing a waveguide which has a shape which follows the exterior of the first dielectric material.

86. (Amended) A microwave plasma processing method wherein a substrate is placed in a microwave plasma processing apparatus comprising a plasma generation chamber provided with a first dielectric material; a substrate support for the substrate to be processed; an endless annular wave guide provided outside of said plasma generation chamber and provided with plural slots for irradiating microwaves therethrough; gas inputs to introduce gas into said plasma generation chamber; and an evacuation system situated to permit pressure reduction in said plasma generation chamber, wherein the interior of said wave guide is filled with a second dielectric material which is the same as or different from the first dielectric material, so that the wavelength of microwaves in said wave guide is shortened, thereby effecting a plasma process.

87. A microwave plasma processing method according to claim 86, wherein the microwaves are introduced utilizing a cylindrically-shaped wave guide.

88. A microwave plasma processing method according to claim 86, wherein the microwaves are introduced utilizing a disk-shaped wave guide.

89. A microwave plasma processing method according to claim 86, wherein the microwaves are introduced utilizing a waveguide which has a shape which follows the exterior of the first dielectric material.

90. A microwave processing method according to any one of claims 78-89, wherein a ratio of the dielectric constants of said first and second dielectric materials is approximately equal to a reciprocal of a square of a ratio of circumferential lengths of said first and second dielectric materials.

91. A microwave processing method according to any one of claims 78-89, wherein said plasma process is effected under application of a magnetic field.

92. A microwave processing method according to claim 91, wherein the magnetic field in a vicinity of the slots has a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

93. A microwave processing method according to any one of claims 78-89, comprising a step of placing said substrate on said substrate support at a position distant from a generation area of said plasma.

94. A microwave processing method according to any one of claims 78-89, wherein the plasma process is effected under irradiation of the substrate with optical energy.

95. A microwave processing method according to any one of claims 78-89, wherein the plasma process is effected by supplying high frequency to said support means.

96. A microwave processing method according to any one of claims 78-89, wherein said plasma process is film forming.

97. A microwave processing method according to any one of claims 78-89, wherein said plasma process is etching.

98. A microwave processing method according to any one of claims 78-89, wherein said plasma process is ashing.

99. (New) A microwave plasma processing apparatus according to claim 19, wherein a spacing between selected slots of said plurality of slots is one half of a guide wavelength of microwaves in said annular waveguide.

100. (New) A microwave plasma processing apparatus according to claim 99, wherein adjacent slots of said plurality of slots are at a spacing of one half or one quarter of a guide wavelength of microwaves in said annular waveguide.

101. (New) A microwave processing apparatus according to claim 60, wherein a spacing between selected slots of said plurality of slots is one half of a guide wavelength of microwaves in said annular waveguide.

102. (New) A microwave plasma processing apparatus according to claim 101, wherein adjacent slots of said plurality of slots are at a spacing of one half or one quarter of a guide wavelength of microwaves in said annular waveguide.

103. (New) A microwave processing apparatus according to claim 68, wherein a spacing between selected slots of said plurality of slots is one half of a guide wavelength of microwaves in said annular waveguide.

104. (New) A microwave plasma processing apparatus according to claim 103, wherein adjacent slots of said plurality of slots are at a spacing of one half or one quarter of a guide wavelength of microwaves in said annular waveguide.

105. (New) A microwave plasma processing method according to claim 78, wherein a spacing between selected slots of said plurality of slots is one half of a guide wavelength of microwaves in said annular waveguide.

106. (New) A microwave plasma processing method according to claim 105, wherein adjacent slots of said plurality of slots are at a spacing of one half or one quarter of a guide wavelength of microwaves in said annular waveguide.

107. (New) A microwave plasma processing method according to claim 86, wherein a spacing between selected slots of said plurality of slots is one half of a guide wavelength of microwaves in said annular waveguide.

108. (New) A microwave plasma processing method according to claim 107, wherein adjacent slots of said plurality of slots are at a spacing of one half or one quarter of a guide wavelength of microwaves in said annular waveguide.

109. (New) A microwave plasma processing method according to claim 50, wherein a spacing between selected slots of said plurality of slots is one half of a guide wavelength of microwaves in said annular waveguide.

110. (New) A microwave plasma processing method according to claim 108, wherein adjacent slots of said plurality of slots are at a spacing of one half or one quarter of a guide wavelength of microwaves in said annular waveguide.

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